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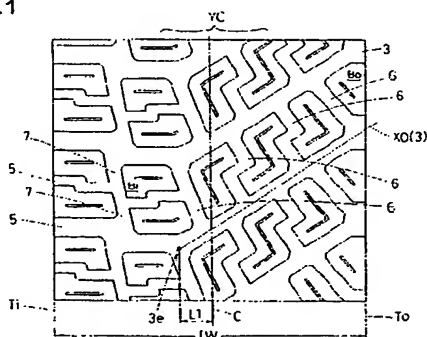
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(54) **Pneumatic tyre**

(57) A pneumatic tyre (1) comprises: a tread portion provided with an asymmetric block pattern having an inside tread edge (Ti) and an outside tread edge (To) to be placed on the inside and outside of a vehicle, respectively; outside lateral grooves (3) extending from the outside tread edge (To) to a tread centre region (YC), each having a groove centre line X0 inclined towards one direction with respect to the tyre circumferential direction (C) at an angle  $\theta 0$  of from 40 to 60 degrees with respect to the tyre circumferential direction (C); inside lateral grooves (5) extending from the inside tread edge (Ti) to the tread centre region (YC), each having a groove centre line X5 inclined at an angle  $\theta 5$  of from 70 to 100 degrees with respect to the tyre circumferential direction (C); each portion between the circumferentially adjacent

outside lateral grooves (3) being divided into outside blocks (Bo) by first to fourth outside connecting grooves (6) extending thereacross; the first outside connecting groove (6A) having a first groove centre line (X1), the second outside connecting groove (6B) having a second groove centre line (X2), the third outside connecting groove (6C) having a third groove centre line (X3), the fourth outside connecting groove (6D) having a fourth groove centre line (X4), and the first to fourth groove centre lines X1 to X4 inclined reversely to the groove centre lines (X0) of the outside lateral grooves (6) with respect to the tyre circumferential direction (C), and the inclination angles  $\theta 1$  to  $\theta 4$  of the first to fourth groove centre lines X1 to X4 with respect to the tyre circumferential direction (C) being in a range of from 20 to 50 degrees and being different from each other.

Fig.1



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## Description

[0001] The present invention relates to a pneumatic tyre, more particularly to an asymmetrical tread pattern which can be employed in both of right tyre and left tyre to improve off-road grip during high-speed running and which is suitable for racing use such as rally, dirt trial and the like.

[0002] In the laid-open Japanese patent application JP-A-11-268506 (corresponding to EP 0943464 A2), a pair of asymmetrical tread patterns specialised for right tyre and left tyre to improve off-road grip were proposed by the present inventor.

[0003] Under actual conditions in rally, dirt trial or the like, there are many occasions such that the tyre is punctured, and a tyre on one side of the vehicle wears more than a tyre on the other side. In the former case, the vehicle must be equipped with two spares for right and left tyres. In the later case, if the worn tyre and the less worn tyre are exchanged in their positions to even the wear, various performances are spoilt due to the directional tread patterns.

[0004] It is therefore, an object of the present invention to provide a pneumatic tyre which can be used on both sides of a vehicle and which has a tread pattern capable of providing improved off-load grip such as traction, braking and side grip.

[0005] According to the present invention, a pneumatic tyre comprises a tread portion provided with a block pattern asymmetric about the tyre equator, the tread portion having an inside tread edge and an outside tread edge to be placed on the inside and outside of a vehicle, respectively, characterised by outside lateral grooves extending from the outside tread edge to a tread centre region, each having a groove centre line X0 inclined towards one direction with respect to the tyre circumferential direction at an angle  $\theta 0$  of from 40 to 60 degrees with respect to the tyre circumferential direction, inside lateral grooves extending from the inside tread edge to the tread centre region, each having a groove centre line X5 inclined at an angle  $\theta 5$  of from 70 to 100 degrees with respect to the tyre circumferential direction, each portion between the circumferentially adjacent outside lateral grooves being divided into outside blocks by outside connecting grooves extending thereacross, the outside connecting grooves comprising a first groove, a second groove, a third groove and a fourth groove arranged in this order from the outside tread edge toward the inside tread edge, the first outside connecting groove having a first groove centre line X1, the second outside connecting groove having a second groove centre line X2, the third outside connecting groove having a third groove centre line X3, the fourth outside connecting groove having a fourth groove centre line X4, the first to fourth groove centre lines X1 to X4 inclined reversely to the groove centre lines X0 of the outside lateral grooves with respect to the tyre circumferential direction, and the inclination angles  $\theta 1$  to  $\theta 4$  of the first to fourth groove centre lines X1 to X4 with respect to the tyre circumferential direction being in a range of from 20 to 50 degrees and being different from each other.

[0006] An embodiment of the present invention will now be described in detail in conjunction with the accompanying drawings:

Fig.1 shows a tread pattern according to the present invention;

Fig.2 is an enlarged view of a part between the lateral grooves thereof;

Fig.3 is a schematic view showing the mounting position and direction of the tyre in relation to a vehicle; and

Fig.4 shows a conventional tread pattern used in a comparative test.

[0007] A pneumatic tyre 1 according to the present invention is designed to be mounted on a vehicle as shown in Fig.3, that is, a tread edge To is position on the outside and a tread edge Ti is position on the inside with respect to the vehicle (hereinafter the "outside tread edge To" and "inside tread edge Ti"). The tyre 1 can be used as the left tyre and right tyre.

[0008] In this specification, the terms "inside" and "outside" will be used to mean the "inside-tread-edge-Ti side" and "outside-tread-edge-To side".

[0009] The pneumatic tyre 1 is provided with tread grooves in the tread portion defined between the outside tread edge To and inside tread edge Ti.

[0010] Fig.1 shows an example of the tread pattern defined by the tread grooves. The tread grooves include:

outside lateral grooves 3 extending from the outside tread edge To into a tread centre region YC;

inside lateral grooves 5 extending from the inside tread edge Ti into the tread centre region YC;

outside connecting grooves 6 extending between the outside lateral grooves 3 to divide each portion between the adjacent outside connecting grooves 6 into outside blocks Bo; and

inside connecting grooves 7 extending between the inside lateral grooves 5 to divide each portion between the adjacent inside lateral grooves 5 into inside blocks Bi.

[0011] Here, the tread centre region YC is a central region of the tread portion having a 40% width of the tread width TW and centred on the tyre equator C.

[0012] It is preferable for both of the traction and side grip that the outside lateral grooves 3 extend beyond the tyre equator C.

[0013] The outside lateral grooves 3 each have a groove centre lines X0 inclined towards the same circumferential direction at an angle  $\theta_0$  of from 40 to 60 degrees with respect to the circumferential direction of the tyre.

[0014] In this example, the inside ends 3e of the outside lateral grooves 3 are positioned on the inside of the tyre equator C at distances L1 of about 10 % of the tread width TW from the tyre equator C. The outside lateral grooves 3 are a substantially straight groove, but a non-linear groove may be also used.

[0015] If the angle  $\theta_0$  is more than 60 degrees, the tread pattern becomes highly directional, and tyre performance shows a large difference between the left turn and right turn, and the steering stability deteriorates. If the angle  $\theta_0$  is less than 40 degrees, the side grip is liable to decrease because the rigidity of the outside blocks Bo decreases.

[0016] In Fig.1, the inclinations of the outside lateral grooves 3 are a right-side upward inclination. Accordingly, all the outside lateral grooves of the tyres mounted on the vehicle are, as shown in Fig.3, also a right-side upward inclination. It is however, possible to provide the outside lateral grooves 3 with a left-side upward inclination. The inclination may be determined according to course conditions in which the tyre is used.

[0017] With respect to the circumferential direction of the tyre, the outside connecting grooves 6 are generally inclined reversely to the outside lateral grooves 3.

[0018] In this example, the outside connecting grooves 6 are a first outside connecting groove 6A, a second outside connecting groove 6B, a third outside connecting groove 6C and a fourth outside connecting groove 6D which are disposed in this order from the outside to the inside, whereby each portion between the circumferentially adjacent outside lateral grooves 3 is divided into a first outside block Bo1, a second outside block Bo2, a third outside block Bo3 and a fourth outside block Bo4 which are disposed in this order from the outside to the inside.

[0019] The outside connecting grooves 6A, 6B, 6C and 6D have groove centre lines X1, X2, X3 and X4 inclined at angles  $\theta_1$ ,  $\theta_2$ ,  $\theta_3$  and  $\theta_4$  in a range of from 20 to 50 degrees with respect to the circumferential direction of the tyre.

[0020] In each portion between the circumferentially adjacent outside lateral grooves 3, the angle  $\theta_1$ , angle  $\theta_2$ , angle  $\theta_3$  and angle  $\theta_4$  are different from each other.

[0021] In an off-road race, there are many occasions to run under a relatively large tyre slip angle. Therefore, it is very important for the tyre to display a large side grip which is stable under a wide range from zero slip angle during straight running to a large slip angle during cornering. By changing the angles  $\theta_1$ - $\theta_4$ , it becomes possible to match one of the outside connecting grooves 6A-6D with the slip angle to derive a maximum side grip under a wide range of running conditions.

[0022] If the angles  $\theta_1$ - $\theta_4$  are less than 20 degrees, vehicle control is liable to become difficult at a small slip angle. If more than 50 degrees, the edges of the blocks excessively decrease in respect of the total circumferential component and it becomes difficult to obtain the necessary side grip.

[0023] In each portion between the circumferentially adjacent outside lateral grooves 3, the angles  $\theta_1$ ,  $\theta_2$ ,  $\theta_3$  and  $\theta_4$  preferably increase from the outside to the inside, i.e. ( $\theta_1 > \theta_2 > \theta_3 > \theta_4$ ) This relation may improve the steering response and helps to reduce uneven wear between the outside blocks.

[0024] If the differences between the angles  $\theta_1$ - $\theta_4$  are too small, the side grip tends to show a peak under a specific running condition. Therefore, the small controllability decreases, and as a result, the side grip as whole tends to decrease.

[0025] Therefore, the differences between the angles  $\theta_1$ - $\theta_4$ , that is,  $\theta_1$ - $\theta_2$ ,  $\theta_2$ - $\theta_3$ ,  $\theta_3$ - $\theta_4$  are preferably set in a range of at least 5 degrees. Further, it is preferable that these differences are substantially same values whose fluctuation is  $\pm 1$  degrees.

[0026] The outside connecting groove 6 may be a straight groove or a crank-shape groove. In this example, the first and fourth outside connecting grooves 6A and 6D are straight. The second and third outside connecting grooves 6B and 6C are crank-shaped.

[0027] In the case of a crank-shape, it is preferable that a middle segment 21, which connects two main segments 20 with each other, extends substantially parallel with the outside lateral grooves 3, and the difference between the angle  $\theta_A$  of the groove centre line XA of the middle segment 21 and the angle  $\theta_0$  of the adjacent outside lateral groove 3 is less than 10 degrees. Here, the main segments 20 are defined as having the groove centre line (X1, X2, X3 or X4) inclined at the above-mentioned angle ( $\theta_1$ ,  $\theta_2$ ,  $\theta_3$  or  $\theta_4$ ).

[0028] As to the shapes of the first to fourth outside blocks Bo1 to Bo4 in this example, as shown in Fig.2, the first outside block Bo1 is generally a triangle, the second outside block Bo2 is a L-shape, the third outside block Bo3 is a S-shape or a crank shape, and the fourth outside block Bo4 is a L-shape.

[0029] The above-mentioned inside lateral grooves 5 extend from the inside tread edge Ti into the tread centre region TC. The inside lateral groove 5 has a groove centre line X5 inclined at angle  $\theta_5$  of from 70 to 100 degrees with respect to the circumferential direction of the tyre, wherein, in case of the angle  $\theta_5$  less than 90 degrees, the inclination is reverse to the outside lateral grooves 3. Thus, when the angle  $\theta_5$  is more than 90 degrees, the inclination is the same as the outside lateral grooves 3.

[0030] The pitch number N5 of the inside lateral grooves 5 is more than the pitch number N3 of the outside lateral grooves 3, wherein the pitch number means the number of the grooves around the tyre. In this example,  $N5/N3=2$ , and the inside lateral grooves 5 include inside lateral grooves 5A connected to one of the outside lateral grooves 3, and inside lateral grooves 5B connected to one of the fourth outside connecting grooves 6D. The grooves 5A alternate with the grooves 5B. Thus the outside ends of the inside lateral grooves 5A align with the inside ends of the outside lateral grooves 3, but it is also possible not to align such as the groove 5B.

[0031] Each portion between the circumferentially adjacent inside lateral grooves 5 is divided by at least one inside connecting groove 7 into inside blocks Bi.

[0032] The number of the inside connecting grooves 7 is less than the outside connecting grooves 6. The inside connecting groove 7 are inclined towards the same direction as the outside connecting grooves 6 with respect to the circumferential direction of the tyre. The inside connecting groove 7 has a groove centre line X6 inclined at an angle  $\theta 6$  of more than zero but less than the angle  $\theta 4$  (for example about 10 degrees) with respect to the circumferential direction of the tyre.

[0033] In this example, a straight inside connecting groove 7 is provided. Thus, each portion is divided into two inside blocks Bi1 and Bi2. In order to improve traction, the inside blocks Bi1 and Bi2 are formed to be long in a sideways sense.

[0034] In this example, both the inside lateral grooves 5A and 5B are a bent groove. However, either or both of the inside lateral grooves 5A and 5B may be a straight groove.

[0035] In the case of a bent groove, it is preferable that the inside lateral groove 5 consists of: main segments 22 which are defined as having the groove centre line X5 inclined at the angle  $\theta 5$ ; and one or more middle segments 23 which are substantially parallel with the inside connecting grooves 7. The difference between the angle  $\theta B$  of the groove centre line XB of the middle segment 23 and the angle  $\theta 6$  of the inside connecting groove 7 is less than 10 degrees. A bent groove similar to the inside lateral groove may be employed in the outside lateral grooves 3.

[0036] As to the shapes of the inside blocks in this example, as shown in Fig.2, all the blocks Bi1 and Bi2 are L-shaped.

[0037] Further, the inclinations of all the inside connecting grooves 7 and outside connecting grooves 6 (main segments 20) gradually decrease from the outside to the inside. In this example,  $\theta 6 < \theta 4 < \theta 3 < \theta 2 < \theta 1$ .

[0038] The widths and depths of the grooves 3, 5, 6, and 7 are usually set in a range of from 4 to 20 mm and a range of from 6 to 15 mm, respectively. In the tread pattern shown in Fig.1, the groove depths of all the grooves 3, 5, 6 and 7 are the same.

### Comparison Tests

[0039] Test tyres of size 205/65R15 were made and tested for traction, side grip, and controllability, and the differences between a left turn and a right turn. Furthermore a lap time was measured on an off-the-road test course. The test course was an unpaved circuit 2.2 km in length. The test car was a 2000cc 4WD car.

[0040] The performances were evaluated into five ranks (standard=3) by the test drivers, wherein the larger the number, the better the performance. The test results and tyre specifications are shown in Table 1.

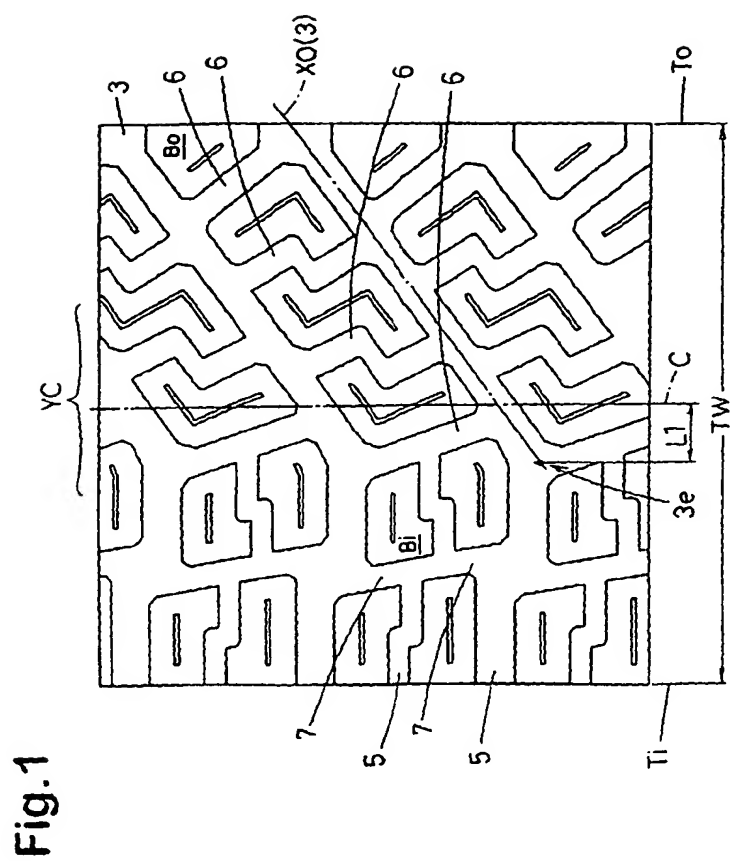
[0041] In Ref.1, the test car was provided on all the wheels with identical tyres having the tread pattern shown in Fig.4. In the others examples, the test car was provided on all the wheels with identical tyres having the tread pattern shown in Fig.1.

Table 1

	Ref.1	Ex.1	Ref.2	Ref.3	Ref.4
Groove inclinations					
$\theta 0$ (deg)	--	55	55	70	30
$\theta 5$ (deg)	--	90	90	90	90
$\theta 1$ (deg)	--	40	15	40	40
$\theta 2$ (deg)	--	34	15	34	34
$\theta 3$ (deg)	--	27	15	27	27
$\theta 4$ (deg)	--	20	15	20	20
Side grip	3	4	4	4	2.5
Traction	3	4	4	4	3
Controllability	3	4	2.5	2.5	2.5
Difference	3	3	3	2.5	3
Lap time	1'36"2	1'34"5	1'35"6	1'36"0	1'36"4

## Claims

1. A pneumatic tyre (1) comprising a tread portion provided with a block pattern asymmetric about the tyre equator (C), said tread portion having an inside tread edge (Ti) and an outside tread edge (To) to be placed on the inside and outside of a vehicle, respectively, characterised by outside lateral grooves (3) extending from the outside tread edge (To) to a tread centre region (YC), each said outside lateral groove (3) having a groove centre line (X0) inclined towards one direction with respect to the tyre circumferential direction at an angle  $\theta_0$  of from 40 to 60 degrees with respect to the tyre circumferential direction (C), inside lateral grooves (5) extending from the inside tread edge (Ti) to the tread centre region (YC), each said inside lateral groove (5) having a groove centre line (X5) inclined at an angle  $\theta_5$  of from 70 to 100 degrees with respect to the tyre circumferential direction (C), each portion between the circumferentially adjacent outside lateral grooves (3) being divided into outside blocks (Bo) by outside connecting grooves (6) extending thereacross, said outside connecting grooves (6) comprising a first groove (6A), a second groove (6B), a third groove (6C) and a fourth groove (6D) arranged in this order from the outside tread edge (To) toward the inside tread edge (Ti), the first outside connecting groove (6A) having a first groove centre line (X1), the second outside connecting groove (6B) having a second groove centre line (X2), the third outside connecting groove (6C) having a third groove centre line (X3), the fourth outside connecting groove (6D) having a fourth groove centre line (X4), the first to fourth groove centre lines X1 to X4 being inclined reversely to the groove centre lines X0 of the outside lateral grooves with respect to the tyre circumferential direction (C), the inclination angles  $\theta_1$  to  $\theta_4$  of the first to fourth groove centre lines X1 to X4 with respect to the tyre circumferential direction (C) being in a range of from 20 to 50 degrees and being different from each other.
2. A pneumatic tyre according to claim 1, characterised in that the angles  $\theta_1$ ,  $\theta_2$ ,  $\theta_3$  and  $\theta_4$  of the first, second, third and fourth outside connecting grooves (6A, 6B, 6C, 6D,) respectively, satisfy the following condition:  $\theta_1 > \theta_2 > \theta_3 > \theta_4$ .
3. A pneumatic tyre according to claim 2, characterised in that angle differences  $\theta_1 - \theta_2$ ,  $\theta_2 - \theta_3$  and  $\theta_3 - \theta_4$  are not less than 5 degrees.



**Fig. 2**

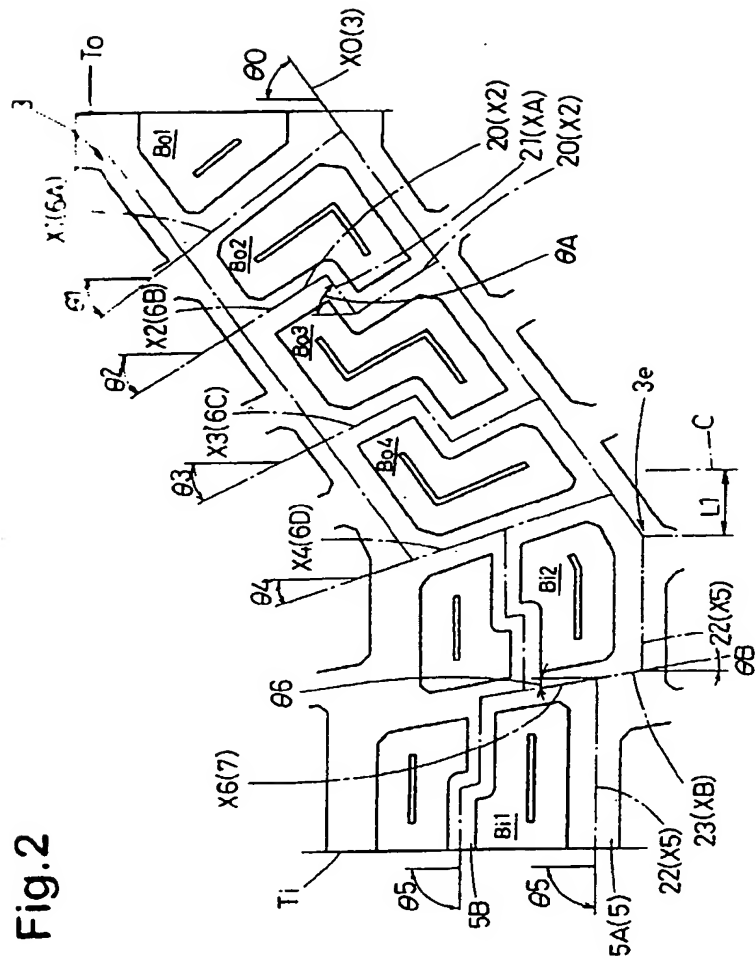
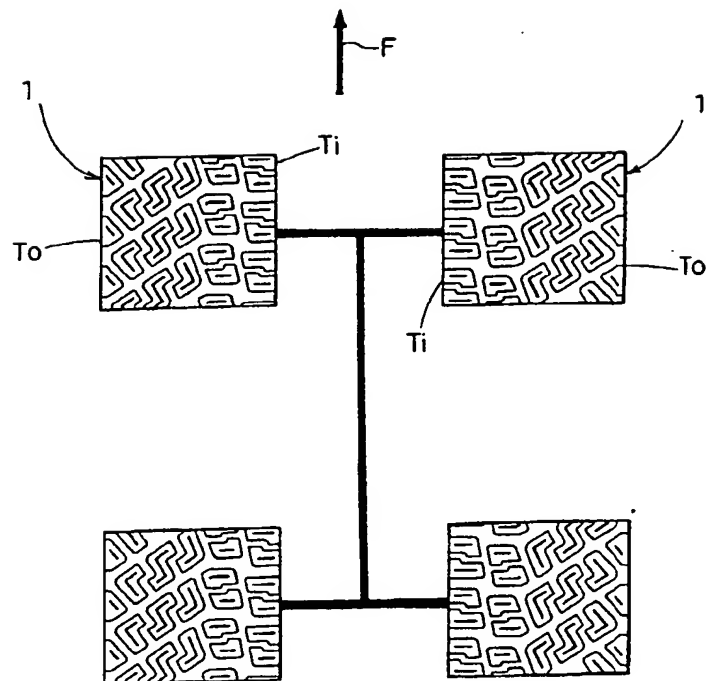
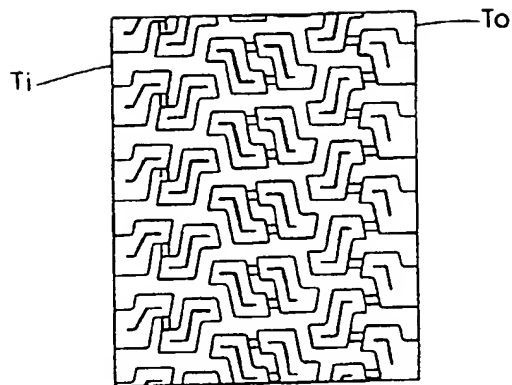
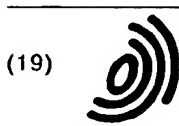


Fig.3



**Fig.4**





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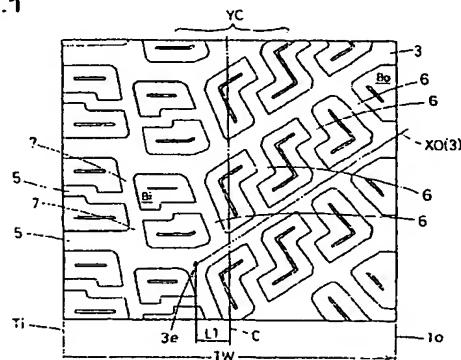
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grees and being different from each other.

**Fig.1**



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## EUROPEAN SEARCH REPORT

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (InLCI.7)
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			TECHNICAL FIELDS SEARCHED (InLCI.7)
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The present search report has been drawn up for all claims			
Place of search THE HAGUE		Date of completion of the search 21 May 2001	Examiner Bibollet-Ruche, D
CATEGORY OF CITED DOCUMENTS		T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document	
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